

## SPECIFICATION

## ULTRASONIC PROBE

## 5 TECHNICAL FIELD

The present invention relates to an ultrasonic probe for inserting an ultrasonic transducer into a body cavity and emitting ultrasonic waves into an organism and then  
10 receiving an echo signal thereof, and more particularly relates to an ultrasonic probe that, in order to swing an ultrasonic transducer placed inside an insertion portion to be inserted into a body cavity, transmits a rotation of a motor,  
15 which is placed inside a grip portion held by an operator outside the body cavity, to the ultrasonic transducer.

## BACKGROUND ART

20 As a conventional ultrasonic probe, for example, as described in the following patent documents 1, 2 and 3, a method of transmitting a rotation of a motor through a wire to an ultrasonic transducer is known. Fig. 8 shows a  
25 sectional view of the conventional ultrasonic

probe. Inside a grip portion 1, a motor 5 and a pulley 102 linked to its rotation shaft are placed. Inside a tip portion 3 of an insertion portion 2, an ultrasonic transducer 4 and a pulley 7 linked to its rotation shaft 9 are placed. Then, an endless wire 8 is laid between the pulleys 102, 7, and the rotation of the motor 5 is transmitted to the rotation shaft 9 of the ultrasonic transducer 4.

10            Patent Document 1: Japanese Patent  
Application publication (H10-179588)  
(Fig. 3, Paragraph 0049)

             Patent Document 2: Japanese Patent  
Application publication (H10-174686)  
15            (Fig. 1, Paragraph 0052)

             Patent Document 3: Japanese Patent  
Application publication (2001-170053)  
(Fig. 2, Paragraph 0010)

             However, in the foregoing conventional  
20            ultrasonic probe, the wire 8 is laid so as to be  
extended from the grip portion 1 to the tip  
portion 3 of the insertion portion 2, and it is  
relatively long. Thus, this has a problem that  
looseness of the wire 8 is generated, which causes  
25            a positional error of the ultrasonic transducer 4.

## DISCLOSURE OF THE INVENTION

The present invention solves the foregoing conventional problems and has an object to provide  
5 an ultrasonic probe that can reduce the looseness of a wire and reduce the positional error of an ultrasonic transducer.

In order to attain the foregoing object, the present invention is configured such that an  
10 ultrasonic probe for transmitting a rotation of a motor, which is placed inside a grip portion in order to swing an ultrasonic transducer placed inside a tip portion of a longitudinal insertion portion, to the ultrasonic transducer, includes:

15 a rotation shaft linked to a rotation shaft of the motor so that a tip is extended inside the tip portion of the insertion portion;

a first pulley attached to a tip of the rotation shaft;

20 a second pulley attached to a swinging shaft of the ultrasonic transducer;

a middle pulley placed between the first and second pulleys;

25 a wire laid between the first and second pulleys and the middle pulley; and

a sliding mechanism for sliding the middle pulley and fixing to the tip portion so that the wire is not loosened.

5 With the foregoing configuration, the wire can be made shorter than the conventional example. Thus, the looseness of the wire can be reduced, thereby reducing the positional error of the ultrasonic transducer.

10 Also, this is configured such that the sliding mechanism has:

a slider portion to which the middle pulley is attached and which can be slid in a direction orthogonal to a rotation direction of the first pulley along a slider guide portion formed at the tip portion; and

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a screw for fixing the slider portion to the tip portion.

With the foregoing configuration, the looseness of the wire can be reduced, thereby

20 reducing the positional error of the ultrasonic transducer.

Also, this is configured such that the wire is made of a line material having both ends and has a block for fixing both of the ends of the line material, and the block is attached to the

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first pulley.

With the foregoing configuration, the wire can be easily laid between the first and second pulleys and the middle pulley.

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#### BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a sectional view of an ultrasonic probe in a first embodiment of the present invention;

10 Fig. 2 is a sectional view that enlarges and shows a tip portion of Fig. 1;

Fig. 3A is a sectional view of a situation where a wire at a tip portion of an ultrasonic probe in the first embodiment of the present invention is laid between first and second pulleys;

Fig. 3B is a sectional view of a situation where the wire at the tip portion of the ultrasonic probe in the first embodiment of the present invention is laid in a middle pulley;

Fig. 3C is a sectional view of a situation where the wire at the tip portion of the ultrasonic probe in the first embodiment of the present invention is completely laid;

25 Fig. 4A is a configuration view showing a

plate portion of an ultrasonic probe in a second embodiment of the present invention;

Fig. 4B is a configuration view showing a situation where a wire of the ultrasonic probe in the second embodiment of the present invention is  
5 fixed to the plate portion;

Fig. 4C is a configuration view showing a first pulley of the ultrasonic probe in the second embodiment of the present invention;

10 Fig. 4D is a configuration view showing a situation where the plate portion of the ultrasonic probe in the second embodiment of the present invention is fixed to the first pulley;

Fig. 5 is a sectional view of the  
15 ultrasonic probe in the first embodiment of the present invention;

Fig. 6 is a graph with regard to a wire tension in the first embodiment of the present invention;

20 Fig. 7 is a sectional view (top view) of the ultrasonic probe in the first embodiment of the present invention; and

Fig. 8 is a sectional view of a conventional ultrasonic probe.

## BEST MODE FOR CARRYING OUT THE INVENTION

## &lt;First Embodiment&gt;

Hereinbelow, with reference to the drawings, description will be given about embodiments to the present invention. An ultrasonic probe in the first embodiment of the present invention is shown in Fig. 1, Fig. 2, Fig. 3A, 3B and 3C. At first, in those drawings, a motor 5 is placed inside a grip portion 1, and the motor 5 is configured such that a rotation shaft 10 is extended to a tip portion 3 of an insertion portion 2. Then, a pulley 6 as a first pulley is attached to the tip of the rotation shaft 10 of the motor 5. Around the circumference of the pulley 6, in such a way that a wire 8 does not fall away in a shaft direction, a part is flatly formed, and a plate portion 16 is attached onto its flat surface. A groove 16a for fastening the wire is formed in a circumferential direction between the circumference of the pulley 6 and the plate portion 16. An arc ultrasonic transducer 4 and a pulley 7 as a second pulley linked to its rotation shaft 9 are placed inside the tip portion 3 of the insertion portion 2. The axis direction of the pulley 6 on the motor 5 side and the axis

direction of the rotation shaft 9 on the ultrasonic transducer 4 side are orthogonal.

Inside the tip portion 3 of the insertion portion 2, middle pulleys 11a, 11b are also placed  
5 between the pulleys 6, 7. The middle pulley 11a is attached to a slider portion 14, and the slider portion 14 (and the middle pulley 11a) is supported slidably in the direction orthogonal to the axis of the pulley 6 along a slider guide  
10 portion 15 formed in a base portion 3a of the tip portion 3, and the position of a sliding direction is supported so as to be able to be fixed at the base portion 3a by a screw 13. Those screw 13, slider portion 14 and slider guide portion 15  
15 constitute a sliding mechanism 12 of the middle pulley 11a.

Then, the endless wire 8 is laid between the pulley 6, the middle pulleys 11a, 11b and the pulley 7. Figs. 3A to 3C show the laying method  
20 of the wire 8. At first, as shown in Fig. 3A, in a situation where the slider portion 14 is moved to the looseness direction of the wire, the wire 8 is laid in the pulley 7 on the ultrasonic transducer 4 side, and it is fastened in the  
25 groove 16a (refer to Fig. 2) of the pulley 6 on



the motor 5 side, and it is then laid between the middle pulleys 11a, 11b as shown in Fig. 3B. Next, as shown in Fig. 3C, the slider portion 14 is slid in the fastened direction of the wire and fixed by the screw 13. Thus, the sliding mechanism 12 can protect the looseness of the wire 8 by moving the middle pulley 11a, which is placed between the slider portion 14 and the slider portion 14 with the screw 13, to an arrow direction.

With regard to the ultrasonic probe configured as mentioned above, the operation thereof will be described below. In Fig. 1, outside a body cavity, an operator can hold the grip portion 1 and insert the insertion portion 2 into the body cavity. By using the motor 5, it is possible to perform the rotational motion on the pulley 6 set in the rotation shaft 10, and transmit the rotational motion of the pulley 6 through the middle pulleys 11a, 11b via the wire 8 to the pulley 7, and then perform the swinging motion around the rotation shaft 9 on the ultrasonic transducer 4.

Thus, the wire 8 can be made shorter than the conventional example. Also, in the sliding mechanism 12, since the slider portion 14 where

the middle pulley 11a is set is fixed with the screw 13, the looseness of the wire 8 can be protected. Since the looseness of the wire 8 is decreased, the positional error of the ultrasonic transducer 4 can be reduced, thereby attaining the accurate positioning.

By the way, there may be a plurality of middle pulleys 11a, 11b as shown in the drawings. Also, this embodiment describes the case where the sliding mechanism 12 is placed in one of the two middle pulleys 11a, 11b. However, this is not limited thereto.

#### <Second Embodiment>

The ultrasonic probe in the second embodiment will be described below with reference to Figs. 4A to 4D. At first, as shown in Fig. 4A, an attaching hole 17 of the wire 8 is formed in the plate portion 16. Then, as shown in Fig. 4B, both ends of one wire 8 that has both the ends (is not endless) is inserted into this attaching hole 17, and the plate portion 16 is crushed, thereby fixing both of the ends of the wire 8. On a part of the circumference of the pulley 6, as shown in Fig. 4C, a flat surface 18 is formed. Then, as shown in Fig. 4D, the plate portion 16 is attached

onto this flat surface 18 with a screw 19.

According to this second embodiment, after the wire 8 that is not endless is made endless by the plate portion 16, it is easily attached to the pulley 6.

By the way, in Fig. 5, a notch portion 19 may be formed in the shape of a circle around the second pulley 7, oppositely to a protrusion 20 placed on the base portion 3a. When the ultrasonic transducer 4 receives the impact caused by a drop and the like, it is rotated around the rotation shaft 10, and the protrusion 20 and the end surface of the notch portion 19 are hit. Correspondingly, this can protect the ultrasonic transducer 4 from being hit against the base portion 3a and protect the ultrasonic transducer from being damaged.

By the way, in order to protect the looseness of the wire 8, in the graph of a tension of the wire and an elastic coefficient of the wire in Fig. 6, the tension applied to the wire 8 is desired to be in the range of the tension where an elastic constant  $E1$  is within 30% with respect to an elastic constant  $E0$  where the elastic coefficient of the wire is constant for the

tension. This is because as the elastic modulus of wire is lower, the inertia of the ultrasonic transducer 4 when it is swung causes the wire to be elastically extended, which results in the larger position displacement.

By the way, in Fig. 7, in a diameter  $\Phi d1$  of the first pulley, a diameter  $\Phi d2$  of the second pulley and a distance A between the positions for which the wires of the pulleys where the middle pulleys 11a, 11b are opposite to each other are set,  $\Phi d1 = \Phi d2 = A$  is desired. This is intended such that the wire is set vertically for the rotation axis of any pulley. Consequently, the force that is obliquely applied to the rotation axis of the pulley of the wire can be avoided, thereby reducing the sideslip on the pulley of the wire.

#### INDUSTRIAL APPLICABILITY

As mentioned above, according to the present invention, the wire can be made shorter than the conventional example. Thus, the looseness of the wire can be reduced, and the positional error of the ultrasonic transducer can be reduced. Hence, the present invention is useful for the field of the ultrasonic probe that

is inserted into the body cavity.